THE CLIMATE CONVOCATION

For CSE-GSP's climate change course participants

September 28-30, 2022

Anil Agarwal Environment Training Institute (AAETI), Nimli, Rajasthan

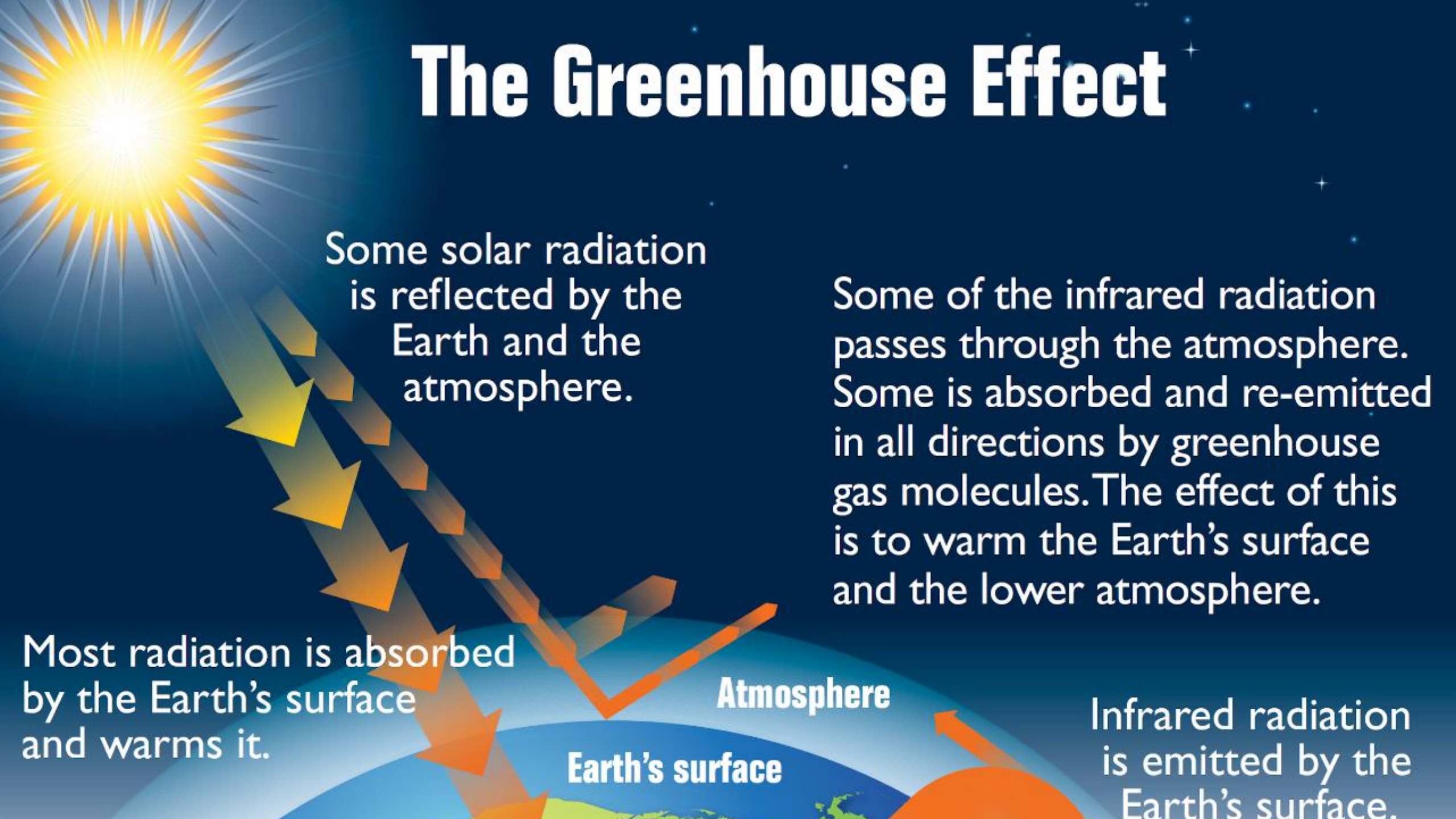
What is Climate?

- Climate is the average weather of a region over long time periods
- It includes things like mean temperature, average rainfall, snow and winds
- Planetary climate, Regional climates, Micro climates

How Humans are Changing Climate?

- Earth's climate has been changing naturally for almost 5 billion years of its history
- But for the past few hundred years, human activities are also causing changes to the climate
- These changes are happening because of greenhouse gas emissions which started after the industrial revolution in the 18th century
- The main greenhouse gases are carbon dioxide, methane, nitrous oxide and water vapour. 74 percent is carbon dioxide.

The Greenhouse Effect



Earth is heating up

- In 2021 the concentration of carbon dioxide was the highest in 3 million years at 416.45 parts per million
- Carbon dioxide is a long living green house gas and traps the heat in the atmosphere
- This has caused the Earth to heat up by 1.09 degree Celsius since pre industrial times (IPCC AR6)
- 2021 was one of the seven warmest years ever recorded despite double La Nina

Impacts of Climate Change

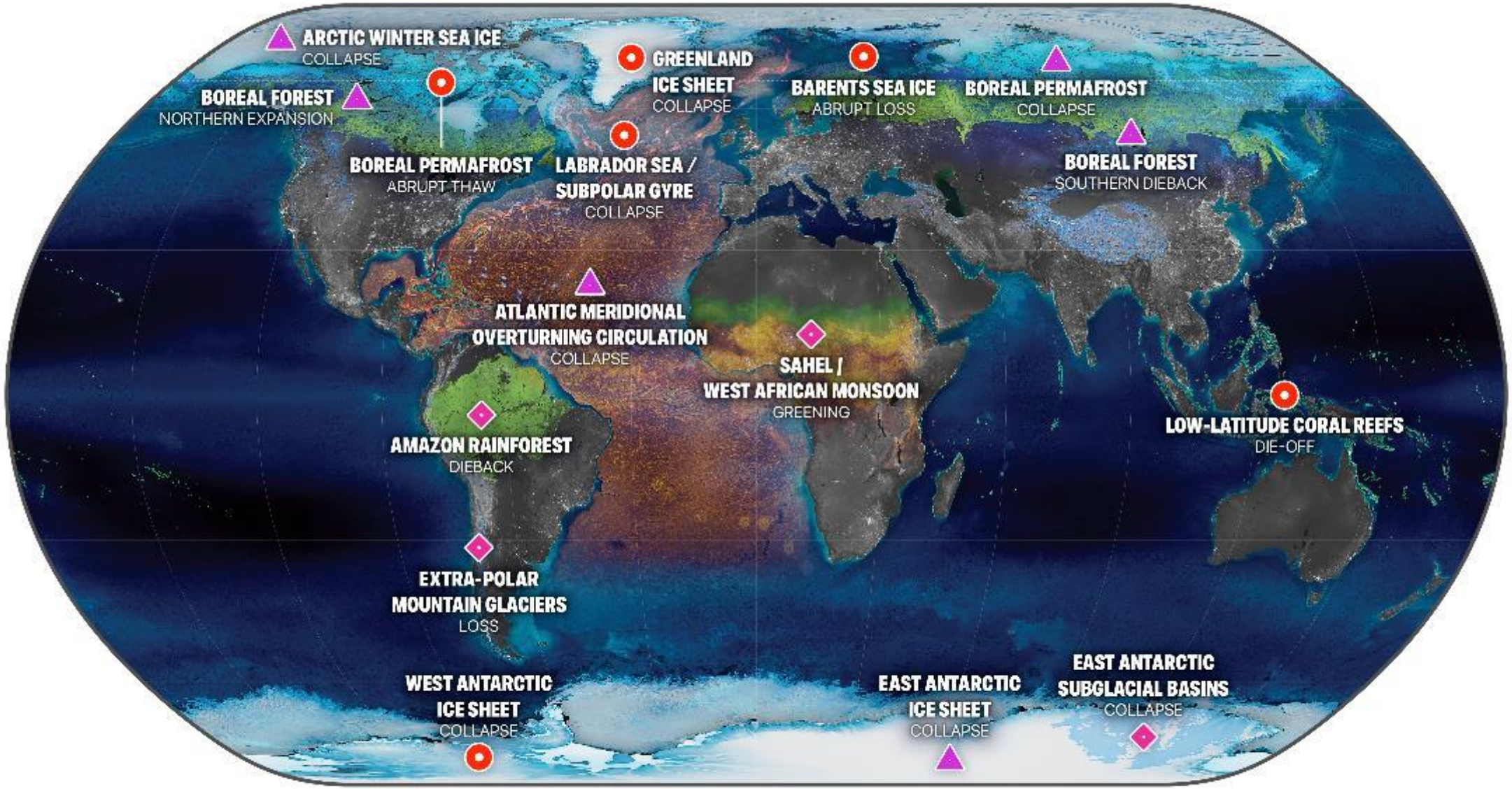
- Changes in rapid onset events of extreme weather like heat waves and cyclones
- Slow onset changes like sea level rise, ocean acidification and droughts
- Both are interlinked in complicated ways and can have long lasting impacts
- Loss of lives, impact on livelihoods such as decreasing agricultural yields, damage to infrastructure, impact on bio diversity, socio cultural changes, human migration, economic impacts and conflicts
- 1970-2019 saw 11,000 climate-related disasters, with 2 million deaths and losses worth $3.6 trillion

Climate Crisis

- Latest IPCC report (August 2021) predicts that Earth might cross 1.5°C warming threshold by 2040
- Under a business as usual scenario a warming of up to 4°C could occur which will be far beyond the point of no return
- Some of the 16 climate tipping points could be crossed faster than thought before and at lower levels of warming (even at 1.09°C)
- These are systems which are crucial for maintaining life on Earth
- Amazon rain forests, boreal forests, permafrost, coral reefs, Atlantic circulations, Greenland ice sheet, East Antarctic and West Antarctic ice sheets

- Many changes to earth's systems are already irreversible.

CLIMATE **TIPPING ELEMENTS**



GLOBAL WARMING THRESHOLDS

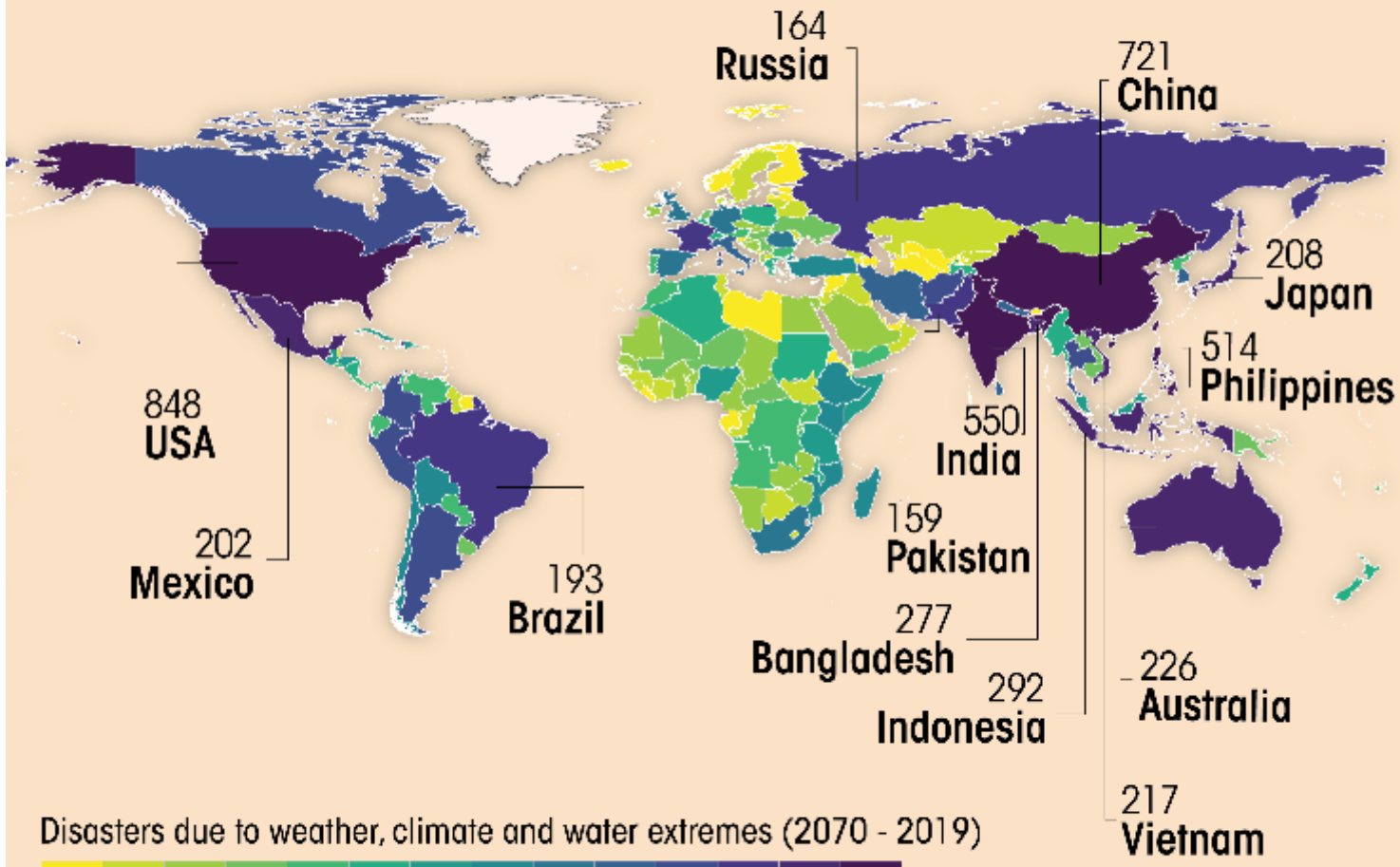
<2°C	2-4°C	≥4°C

Warming affects extreme weather

- Change in character of extreme weather
- Increase in intensity of tropical cyclones, rapid intensification, more rain
- Extreme rainfall events which induce floods, flash floods and landslides
- Dust, hail and thunderstorms with lightning
- Disruption of the monsoon leading to cycles of floods and droughts
- Cold waves and cold days with ground frost
- Heat waves with wild fires and possible drought
- Compound extreme weather events

CLIMATE CHANGE-INDUCED DISASTERS

India ranked 3rd out of 188 countries experiencing disasters due to climate change. Countries from South Asia — Bangladesh(6th), Pakistan (13th), and Nepal(25th) — all featured in the list of 25 worst-hit countries



Source: World Meteorological Organisation

Down To Earth

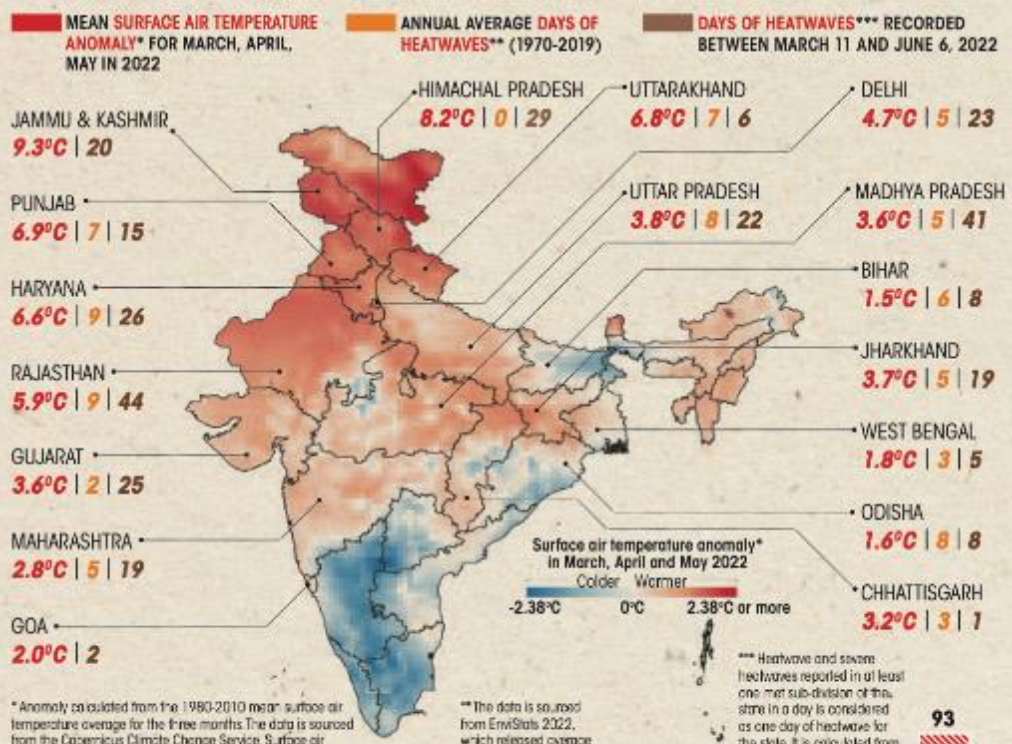
Extreme Weather in India in 2022

- Heat Waves across 17 states from March to June. Spring almost non existent this year.
- The most unlikely impact was in the mountains of Himachal Pradesh, Jammu and Uttarakhand where they became a cause for melting of glaciers. People living in the mountains are not adapted to such heat waves.
- Monsoons came early but were devastating to begin with catastrophic floods in northeast India, especially Assam and Meghalaya, and Bangladesh.
- Throughout the season there were extreme weather events across 26 states that have killed almost 2000 people and caused agriculture losses in 1.8 million hectares.
- Himachal Pradesh was the worst affected among states with 320 deaths because of frequent cloud bursts, flash floods and landslides
- Madhya Pradesh is second worst affected with 280 deaths, 159 due to lightning strikes - highest in the country

THE HEAT IS ON

Till June 6, 2022, as many as 17 states have experienced heatwaves. They have all reported more days of heatwaves than their 50-year annual average (1970-2019). Himachal Pradesh recorded its first heatwave in March, April and May since 1970, with land temperatures 8.2°C higher in March, April and May 2022 than the 1981-2010 average

ANALYSIS BY AKSHIT SANGOMLA AND PULAHA ROY



Harrowing March

India experienced an alarming number of heatwaves and severe heatwaves* this March, which was also the hottest ever on record

* each met sub-division that reported a heatwave and severe heatwave is counted as one case

Source: India Meteorological Department

Extreme Weather Around the World

- Heat waves across the world
- Wildfires in places like the Arctic
- Droughts in Europe, Asia, South America, Africa and North America
- Horn of Africa, Chile and California are undergoing long term droughts
- Recent Hurricanes and Typhoons. Hurricane Fiona affected Canada which does not usually happen. Hurricane Ian (category 4) wiped out the power throughout Cuba and is battering Florida. 2 million have lost power.
- Conditions for rapid intensification of Hurricane Ian were created by warm ocean surface. La Niña may also have aided.
- India-Pakistan heat waves, European heat waves, Pakistan floods and many others have been attributed to climate change by scientists.

Simultaneous Heat Waves

- Simultaneous heat waves across five continents in July and early August - Europe, Asia, North America, Africa and South America
- This happened due to **planetary wave resonance**, also known as atmospheric blocking event, which is connected to Arctic Warming
- Heat waves in Paraguay and Argentina were unusual as it is winter season in the southern hemisphere.
- In North America, Russia and many parts of Europe there were also wildfires.
- In Europe and China the heat waves lead to drying up of rivers and subsequent drought conditions. China is still undergoing unusual Autumn heat waves.

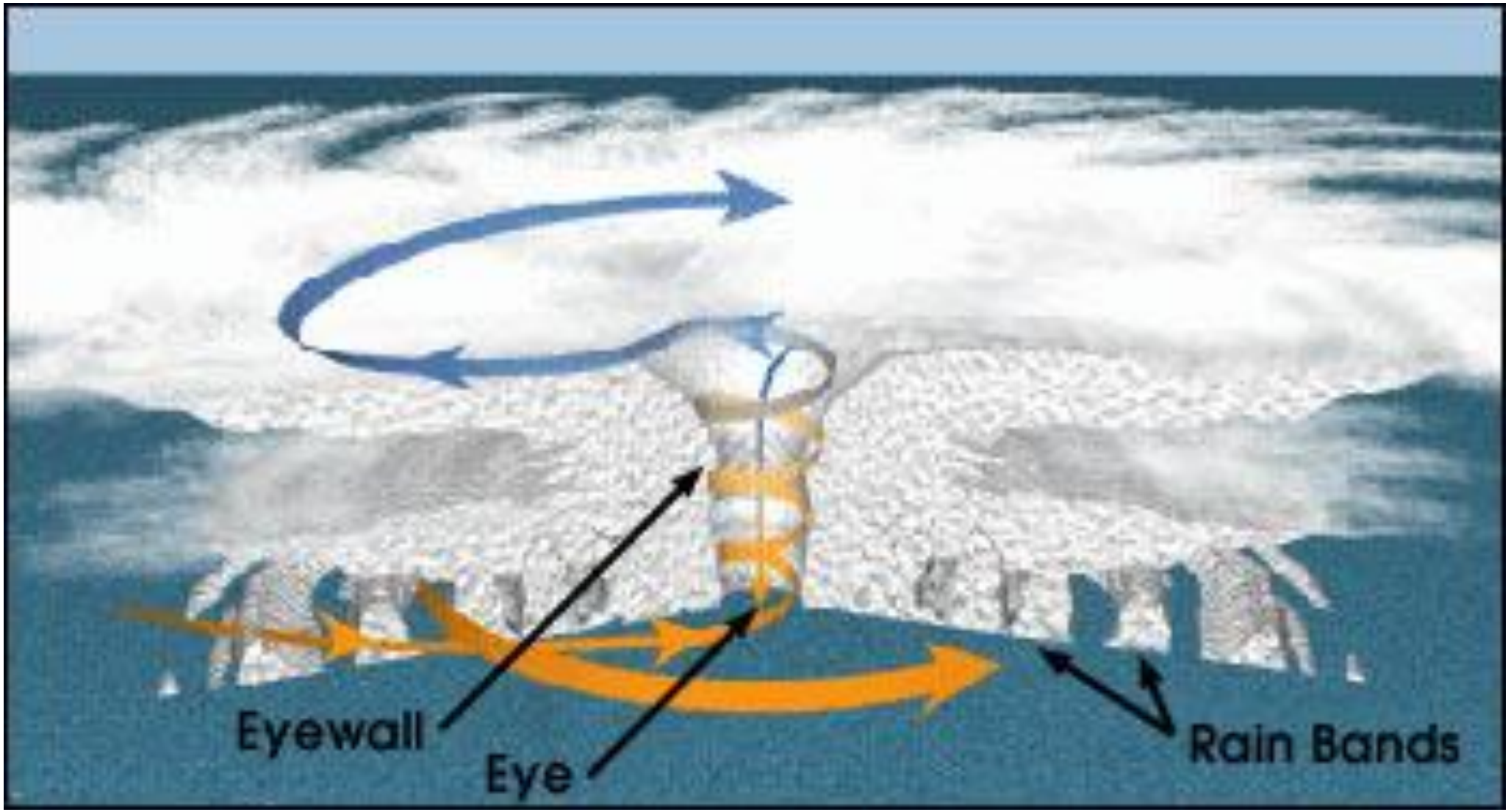
Pakistan Floods

- Glacial melt from the heat waves which shows the interconnectedness of extreme weather events. Heat waves also made the monsoon much more intense than normal.
- 1500 people killed, 7.6 million people temporarily displaced, 1.14 million houses damaged, 18,000 square kilometres of cropland destroyed, mainly cotton, which is the major export.
- Sindh and Balochistan regions were the worst affected with seven and eight times the normal rainfall in August, respectively.
- La Niña phenomenon is responsible to an extent.
- Floods have been attributed to climate change by Scientists. In Sindh and Balochistan rainfall was made 75 percent more intense due to warming.
- Similar floods in 2010 were due to atmospheric blocking event connected to Arctic warming

Cyclones/Hurricanes/Typhoons

- Cyclones are large storms that form over the seas and oceans
- They are also known as hurricanes and typhoons depending on the ocean in which they form
- They need moisture and warm sea surfaces to form
- They carry swift winds and rainfall and cause storm surges along the coasts when they hit land
- Their character is changing as the oceans and lands warm up
- They are more intense, carry more rainfall and move in uncertain ways making it difficult for scientists to track them and inform people about possible damages

Cyclone structure



Scare of a Mega-cyclone

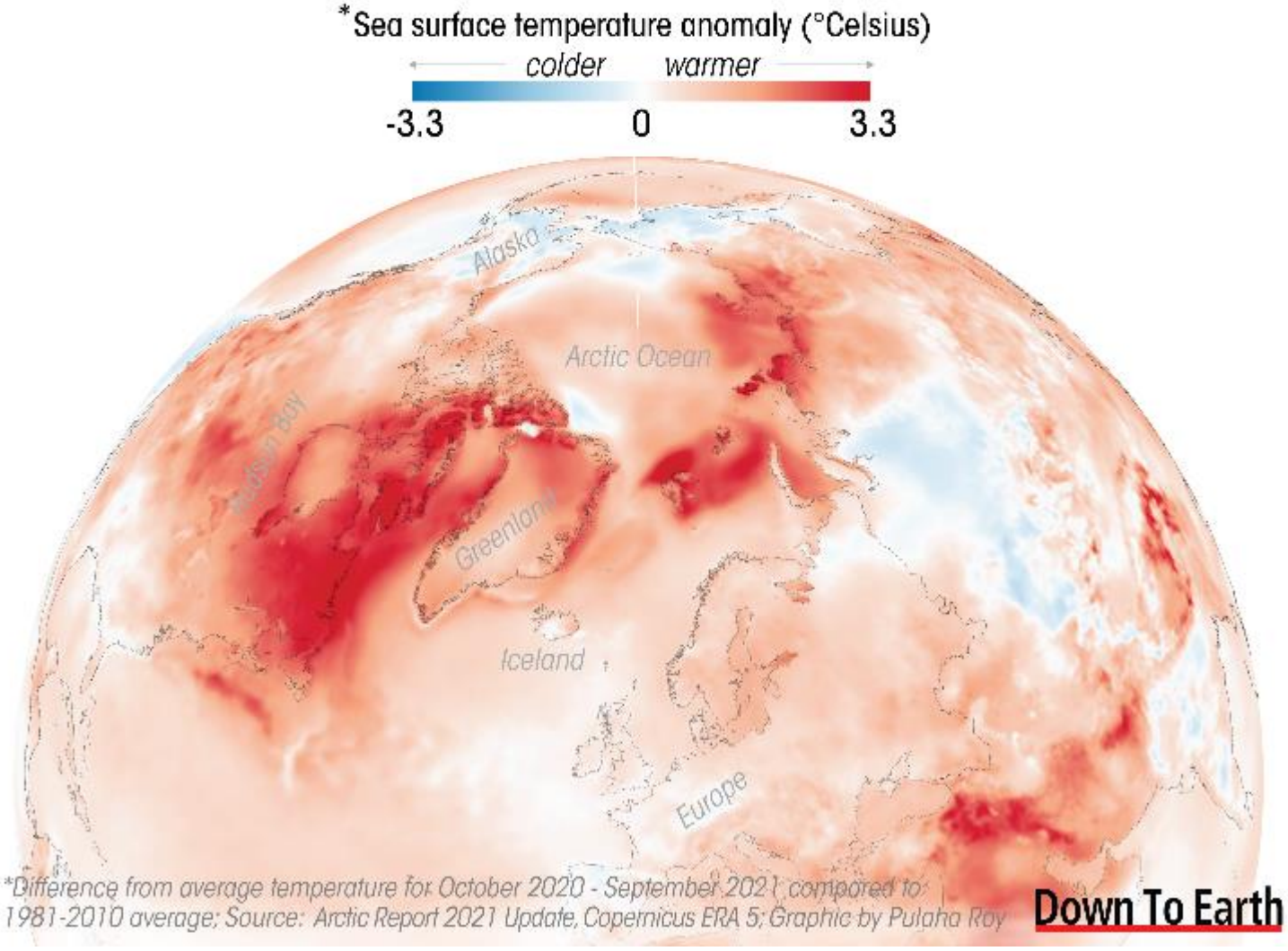
- Super Typhoon Hinnamnor engulfed tropical storm Gardo in the western Pacific Ocean. Such an interaction is called the Fujiwhara Effect. Rare phenomenon
- DTE analysis found only 10 worldwide cases since 1964
- Happens between two tropical storms over the ocean surface which are less than 1,400 km from each other.
- There are five types - elastic interaction, partial straining out, complete straining out, partial merger and complete merger
- In the last type two storms of near equal strength merge together to form a bigger storm
- Warming oceans making it possible for intense storms to form back to back
- Two tropical cyclones that are similar in strength and powerful enough can create a mega-cyclone

Arctic Warming

- Arctic region is the climate capital of the world
- It is warming **four times faster** than the rest of the world *(AGU meeting on December 13, 2021)*
- In parts close to Norway the warming is up to seven times the rest of the world
- Rainfall was recorded for the first time over the Summit Station in Greenland in August, 2021
- Three back to back storms in mid July, a rare event
- Lightning in the Arctic has increased by 8 times in the last decade
- Storms and lightning should be rare in the Arctic because of a lack of heat needed for convection

Tracking Extreme Climate: Arctic

The Arctic Circle, one of the most climatologically important regions on earth, has continued to warm at more than twice the rate as the rest of the world through 2021. The time between October 2020 and September 2021was the seventh warmest since record-keeping began. It was the eighth consecutive year since 2014 when the average temperature of the region was at least 1° Celsius above the pre-industrial average.



*Difference from average temperature for October 2020 - September 2021 compared to 1981-2010 average; Source: Arctic Report 2021 Update, Copernicus ERA 5; Graphic by Pulaha Roy

Down To Earth

Warming Arctic driving extreme weather

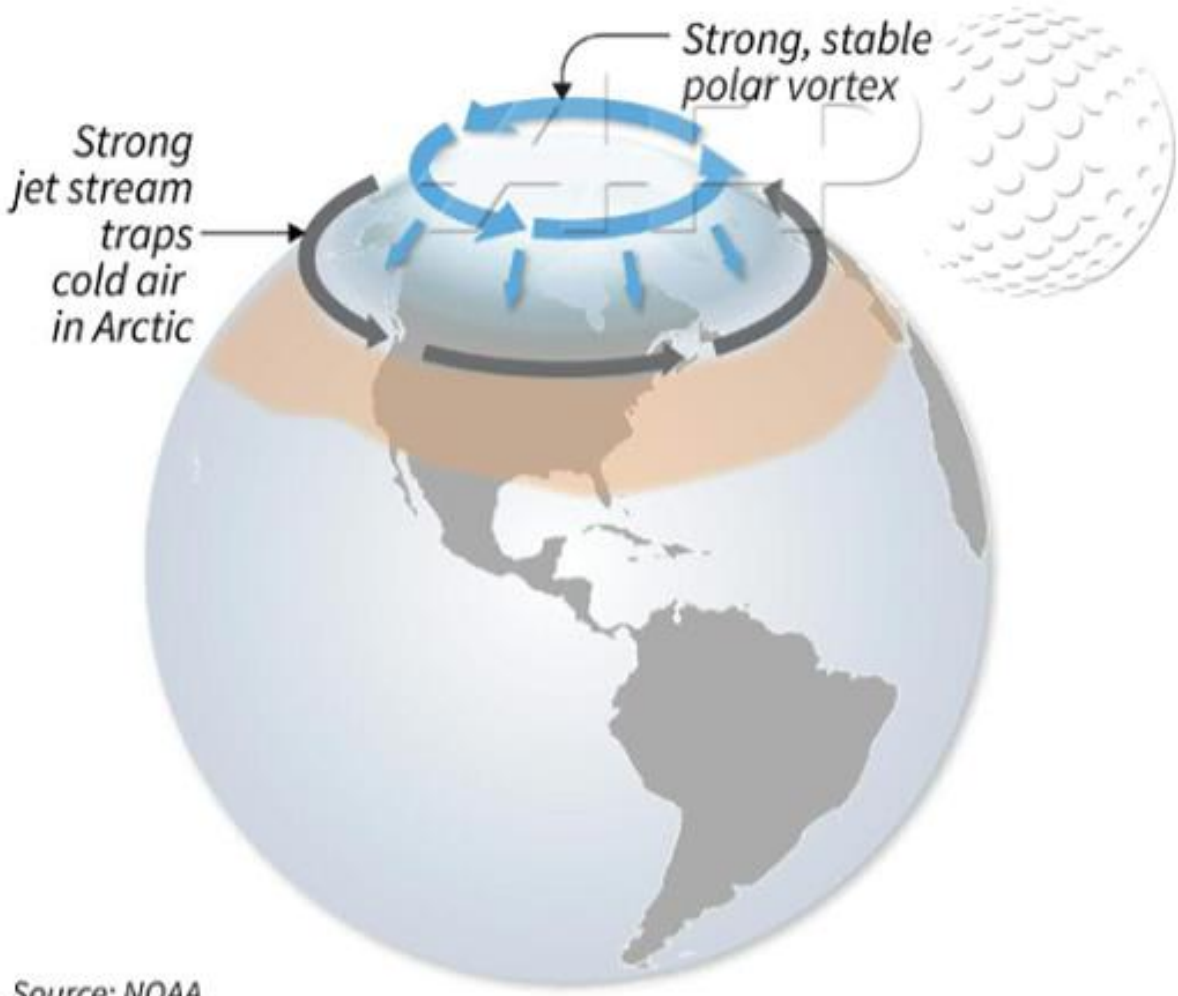
Linked to severe winter storms in US and Europe, heatwave at North Pole

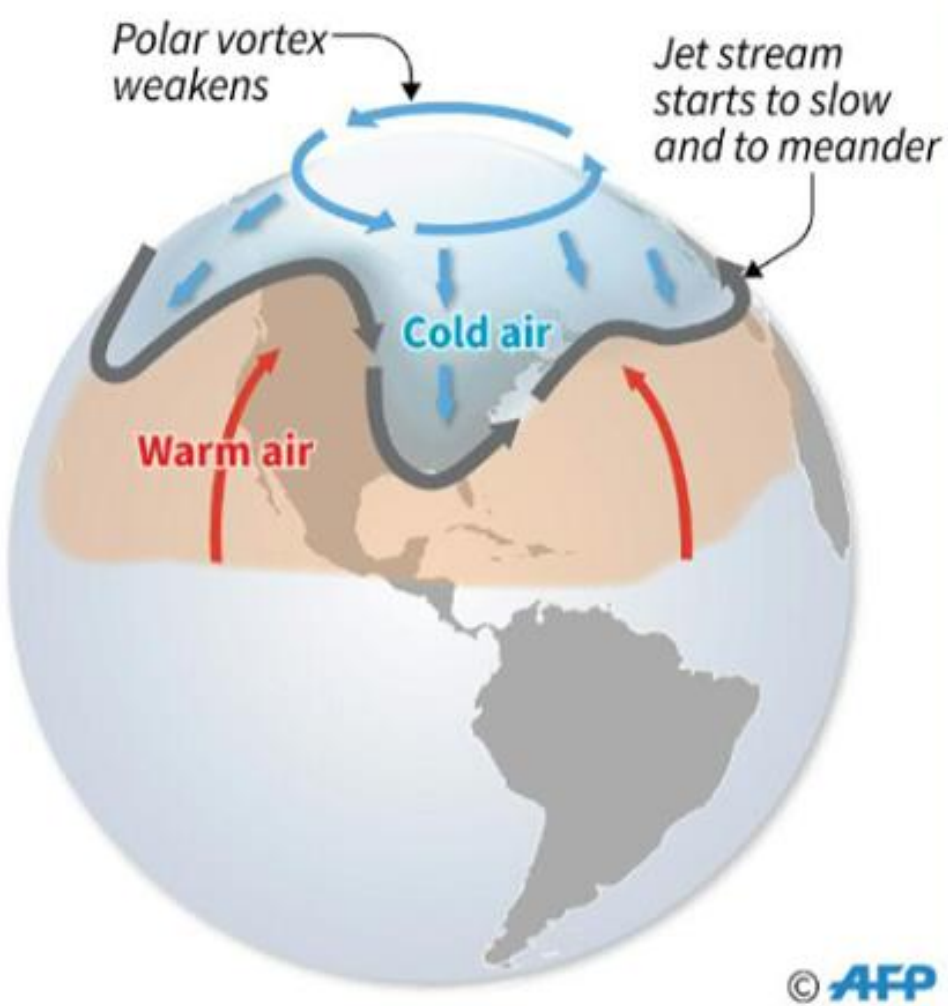
► Normal circumstances

Strong jet stream and polar vortex hold freezing cold air in the Arctic and warm air in lower latitudes

► Arctic warms faster than lower latitudes

Jet stream and polar vortex weaken, allowing Arctic air to move south and warm air to move north





Source: NOAA

Climate Change in North East: **real and visible**

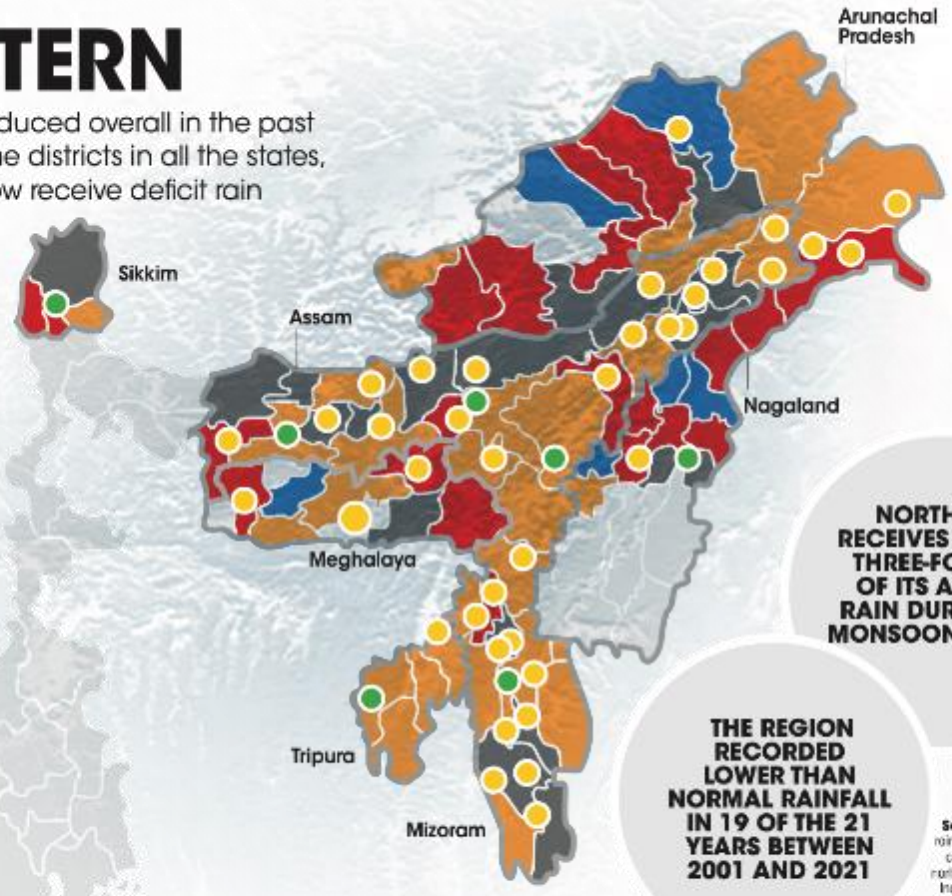
- Temperatures are already rising. Future scenarios seem bleak
- October 2021 was one of the hottest ever recorded
- Rain is major source of water as glaciers are not common. Most of rain during monsoons.
- Rainfall patterns, especially during Monsoon, are changing. Mostly the region is drying up
- In 20 of the last 22 years monsoon rainfall has been below normal
- More than a century long datasets show a declining trend in many states in the region
- The probability of drought occurrence in the region was 54 per cent during 2000-2014

ALTERED PATTERN

Though rainfall in the Northeast has reduced overall in the past three decades, it has increased in some districts in all the states, except Tripura where all the districts now receive deficit rain

LEGEND
(Analysis period 1989-2018)
District-wise rainfall trend for monsoon season
- Increasing significantly
- Increasing but not significant
- Decreasing significantly
- Decreasing but not significant

Trend in frequency of rainy days*
- Significant increase
- Significant decrease



NORTHEAST RECEIVES ALMOST THREE-FOURTHS OF ITS ANNUAL RAIN DURING THE MONSOON SEASON

THE REGION RECORDED LOWER THAN NORMAL RAINFALL IN 19 OF THE 21 YEARS BETWEEN 2001 AND 2021

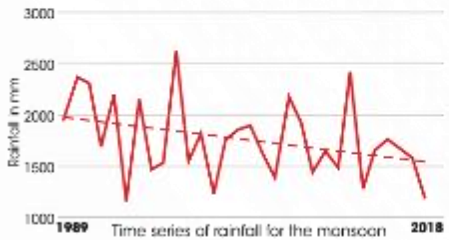
Source: Observed rainfall variability and changes reports for northeastern states by India Meteorological Department. Analysis does not include Manipur due to unavailability of data

* 2.5 mm or more rain in a day

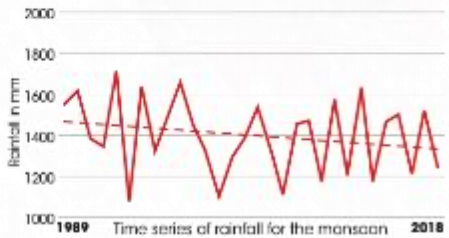
MOSTLY DRY

In six of the eight northeastern states, the overall monsoon rainfall is going down

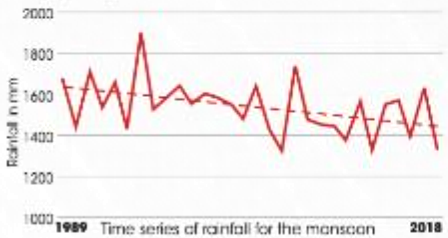
Arunachal Pradesh



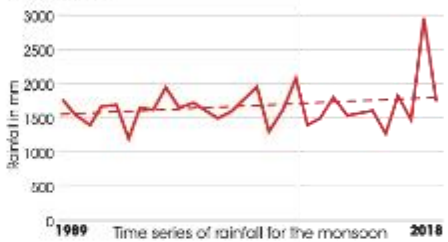
Assam



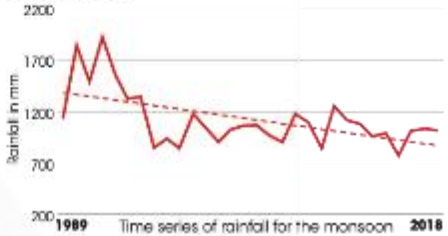
Meghalaya



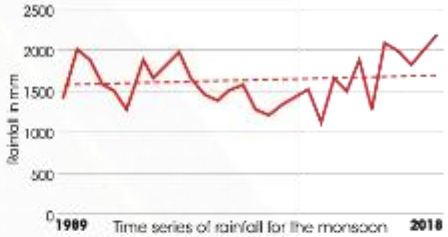
Mizoram



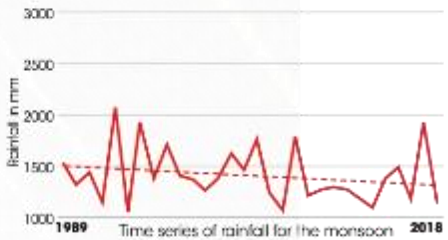
Nagaland



Sikkim



Tripura



Floods in time of drought: vulnerability increasing because of extreme rain events

- Dry periods intermixed with floods
- Extended monsoons in recent years
- More intense rain comes in less time followed by elongated periods of none to very less rainfall
- Heavy to extremely heavy rainfall causes floods, flash floods and landslides.
- Region has lived with floods for a long time
- Flooding patterns are changing, becoming unpredictable for the people
- Short and long term impact of major floods can be witnessed all over the region
- Some places are witnessing floods more often than before

Impacts on Livelihoods

- Rain feeds rivers, streams and springs.
- 27 per cent villages in northeast India are watered directly by springs
- Decrease in spring water has impacted livelihoods like agriculture, horticulture, fishing and animal rearing
- Changes in the varieties of rice cultivated in some regions because of changes in rainfall patterns
- Overall diversity of rice varieties has come down
- New pests and insects being witnessed in some places like Upper Siang in Arunachal Pradesh and Wokha in Nagaland
- More sand than fertile silt brought down by the rivers
- Unpredictable flooding means no long term planning
- Climate induced migration

West Kameng, Arunachal Pradesh

- Construction of a highway in the district has affected the health of springs. Human interventions exacerbate the impacts of climate change
- At least ten springs from Bhalukpong at the Assam-Arunachal Pradesh border to Morgung village in West Kameng have dried up
- Singchung village is witnessing some major changes to its biodiversity and climate indicators due to climate change

Wokha, Nagaland

- In 2018 many villages in the district witnessed floods for the first time in a generation
- Flood waters could still be seen in December 2020
- New pests and insects attacking vegetable and other crops
- Butterflies have decreased in number over the years so have many other small and large animal species that were common earlier
- Fish number and diversity have come down

What needs to be done: Adaptation

- More wide ranging and in depth research into the impacts of climate change in the region
- Study of combined impacts of climate change and other human interventions, especially in the case of the drying mountain springs
- More meteorological stations in the hills and mountains for better analyses and forecasts
- Adaptation strategies will mean community involvement; plans for building resilience and adapting to changes
- Traditional knowledge should be combined with modern science and technology

What needs to be done: Adaptation

- Science based spring rejuvenation should be taken up
- Flood and drought risk analysis and planning should be carried out
- Study of the new types of pests and insects in the agricultural fields should be done and the problem should be addressed scientifically
- Organic agriculture which many parts of the region have always practiced should be further encouraged
- New and innovative livelihood options should also be introduced


Thank you